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(56) Documents cited
US 4931183 A US 4454038 A

(58) Field of search
UK CL (Edition K) C1C CKC CLC CSBA CTBA
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(54) Biological treatment of waste water

(57) There is described a small-sized and low cost waste water biological treating tank especially suitable for domestic installation. The tank 10 contains a porous soft ceramic material 40 which supports the treating microorganisms. Waste or raw water is supplied to the tank from above through a downwardly opening pipe 21, is pushed up by the action of air bubbles generated by a bottom mounted air inlet 30, and then flows over a cylindrical weir 50 into the ceramic material 40 in which the water is purified by microorganisms which digest the nutrient in the water. The surface area of the porous ceramic element 40 is generally about 25 times greater than that of conventional plastics elements. Treated water passes through an outlet 12 and may then be subjected to a centrifugal sludge separation step and an anaerobic biological treatment step (fig. 5).

FIG.1

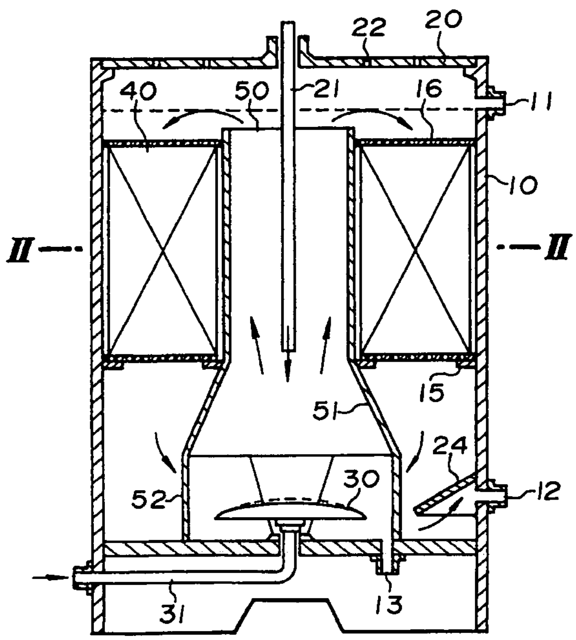

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FIG.1

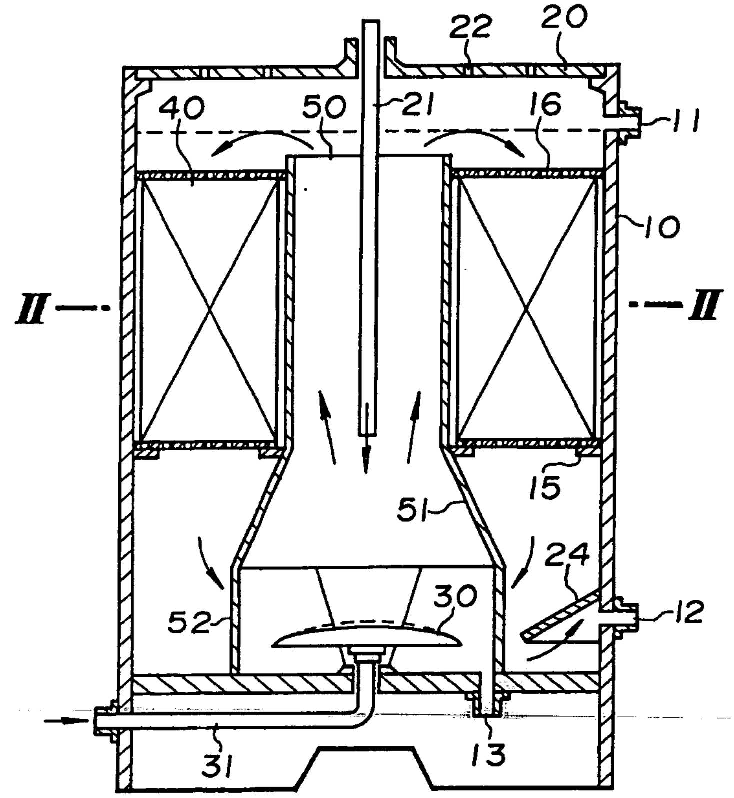


FIG.2

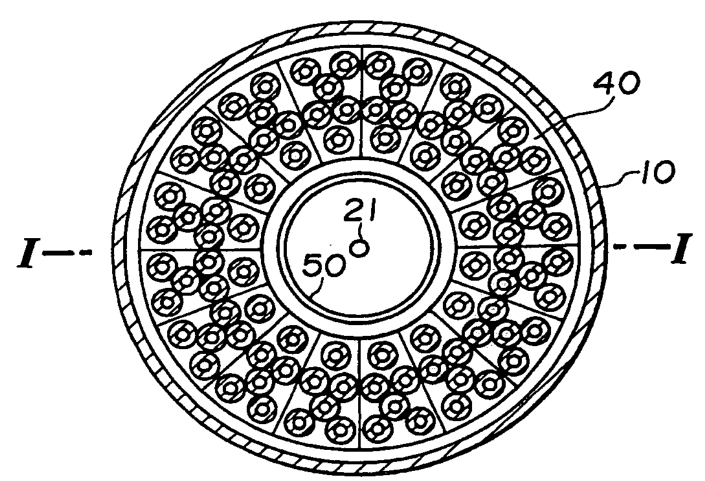


FIG. 3

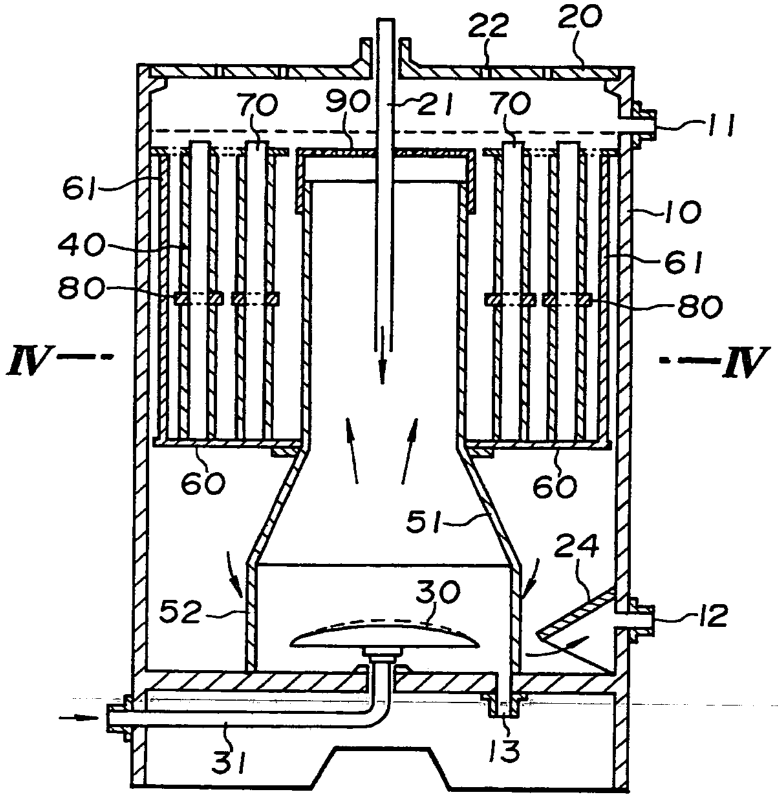

22
20
70
90
21
70
11
61
10
40
61
80
80
IV
IV
60
60
51
24
30
52
12
31
13

FIG. 4

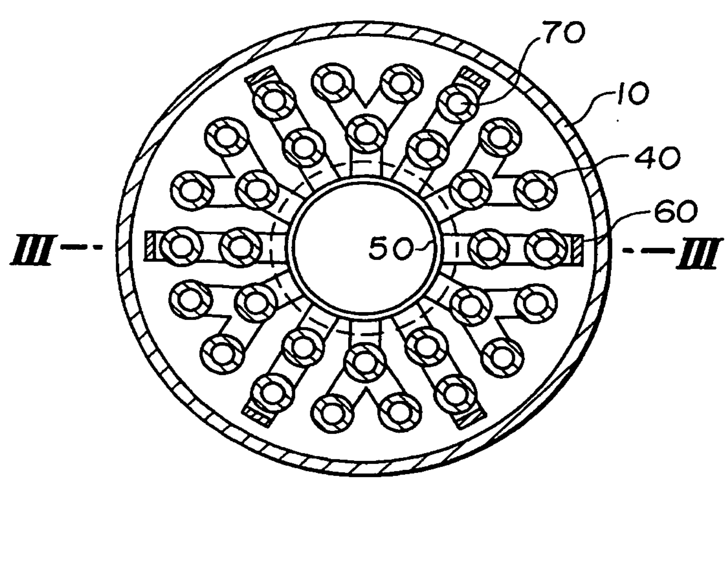
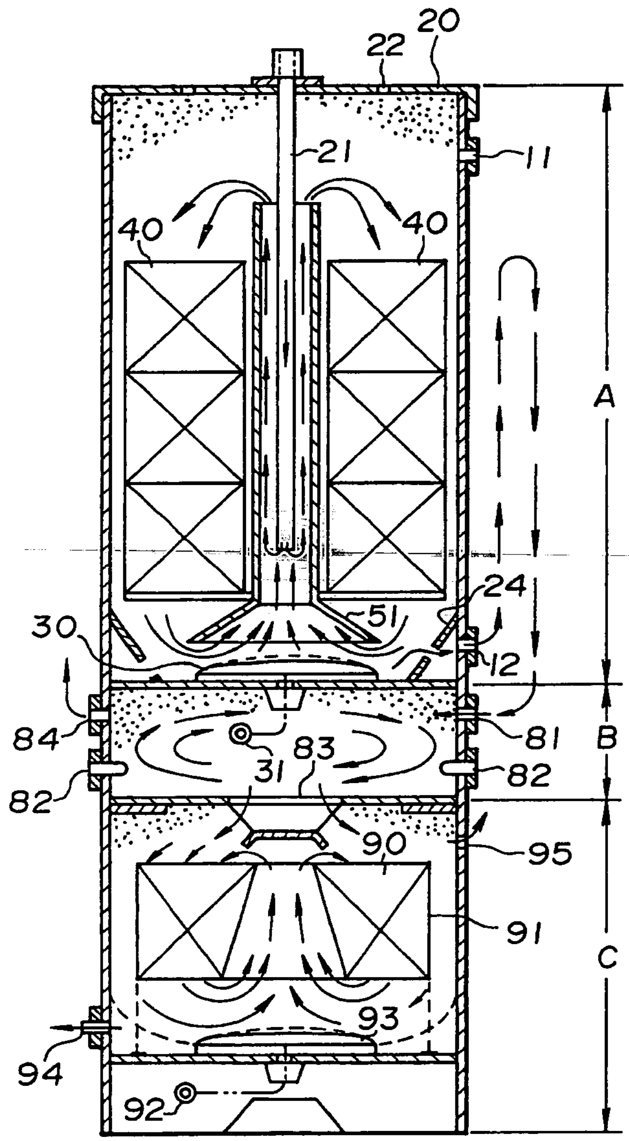

70
10
40
60
III
50
III

FIG.5



WASTEWATER TREATING BIOLOGICAL FILM TANK

In recent years, biological film treatment process has been more deeply recognized and applied again for treating sanitary and industrial wastewaters instead of widely adopted conventional activated-sludge process.

The basic principle of the biological film treatment process consists in that wastewater flows and circulates around a contacting medium whereupon microorganisms accumulates and oxidizingly decompose organic substances included in the wastewater resulting in removing the waste products.

The most important design subject of the biological film treatment process is a contacting element upon which bacterial solids accumulate. Conventionally, the most attempts have been made to maximize surface area for bacterial growth. For example, a rotating biological contactor has employed a plastic contacting element of honeycomb structure having a surface of 200 m^2/m^3.

However, this plastic contacting element has not yet proved to be suitable for bacterial growth and, on the contrary, it hardly allows accumulation of bacteria due to its slippery surface. Furthermore, with thickening of the biological layer on the plastic element, the bacteria in the interior part become to be anaerobic and a large amount of the layer of about 25 mm or more in thickness may fall off

from the plastic element at the same time. This decreases treatment efficiency. The plastic contacting elements have such a disadvantage that they may be clogged unless being spaced at 50 mm or more.

In case of purifying the wastewater by using micro-organisms it is of a great problem how to treat inactive bacteria, that is, dead bodies of the bacteria. In particular, a biological film provided for attachment of bacteria may be clogged with dead bacteria in its pores, thereby it is necessary to exchange the film with new one. It requires maintenance and expenses. For this reason, the equipments for treating the wastewater with biological films have been adopted in the restricted use by the country, local public organizations and big companies and far from the use by the mass people. However, since pollution of rivers and lakes considerably depend upon sanitary waste discharges, it would be greatly improved if every families, individuals and/or medium and small-sized enterprises could treat their liquid wastes by use of said means.

In view of the foregoing, the present invention was made in order to provide a wastewater treating biological film tank and more particularly the same which is so small and low cost to be acquired by an individual and each family, and almost does not require its maintenance.

Figure 1 is a sectional side view for explaining a water treating biological film tank embodying the present invention.

Figure 2 is a sectional view taken along line II-II of Fig. 1.

Figure 3 is a sectional view showing another embodiment of the present invention.

Figure 4 is a sectional view taken along line IV-IV of Fig. 3.

Figure 5 is a sectional view showing another embodiment of the present invention.

Fig. 1 is a sectional side view (a section taken along line I-I of Fig. 2) for explaining a water treating biological film tank embodying the present invention and Fig. 2 is a sectional view taken along line II-II of Fig. 1. The device illustrated in the above-mentioned drawings basically comprises a wastewater treating tank 10, a means 21 for applying wastewater or raw water into the tank 10 from the upper portion thereof, which is practically a waste or raw water supplying pipe removably attached to an upper cover 20 of the tank, a mean 30 for forcing air bubble into the tank 10 from the lower portion thereof in opposition to the above-mentioned waste or raw water, which is practically a air bubble supplying means provided at the lower portion of the tank 10, and biological film elements 40 placed around the periphery of a tank inside area wherein above-

mentioned wastewater or raw water supplied from the top and the air bubbles supplied from the bottom are match with each other. In the tank microorganisms accumulated on the biological film elements 40 may be supplied with a sufficient amount of oxygen from the bottom and a nutrient contained in the wastewater or raw water, in other words, they eat the nutrient in the waste or raw water to be purified.

The above-mentioned biological film elements 40 are of porous material to allow the microorganisms to easily settle thereon and the wastewater or raw water to easily pass therethrough. However, all conventional biological films were also porous but were clogged with dead bacteria in their pores, resulting in exchanging with new ones.

The present applicant has made many and wide research works on the possible causes of clogging of the biological films and found that conventional elements 40 have many blind pores wherein a mass of dead bacteria so accumulated to cause film clogging.

On the other hand, the present applicant has previously proposed multi continuous-pore soft ceramic materials which, as disclosed in Japanese laid open patent publication No. 107582/90, have all pores communicating with each other, and he has applied said ceramic materials as the biological film elements 40.

As expected by the applicant, the test results shows that no biological film element 40 is clogged and requires exchanging itself with new one, i.e., it is realized to

provide an economical wastewater or raw water treating tank which is low cost and easy in maintenance with no additional expenses for periodical exchange of the biological film element 40.

Further referring in detail to the drawings, the treating tank 10 is provided with an overflow outlet 11 at its upper portion, a treated water outlet 12 at its lower side wall and a sludge (drain) outlet at its bottom portion. Floating matters in waste or raw water are taken out through the upper overflow outlet 10, while biological solids and untreated sludge settled on the tank bottom are discharged through the bottom sludge outlet 13. The treated water outlet 12 is provided with water guide partitions 14 at its upper, front and both sides in the tank and allows the treated water to flow out of the tank only through partitions 14 in order to prevent the treated water from being mixed with waste or raw water circulating for treatment in the tank.

In biological film treatment process the contacting medium (biological film) plays the most important part. A conventional plastic contacting medium have such a disadvantage that with thickening biological layer on the plastic medium, the bacteria in inner part becomes to be anaerobic, and a mass of bacteria at the same time slips off from the plastic medium when the layer thickness reaches about 25 mm, thereby the treating efficiency of the plastic film is largely reduced. On the contrary, the tank according to the present invention includes a multi

continuous-pore soft ceramic material disclosed in the Japan laid open patent publication No. 107582/90, which serves as a biological film being capable of realizing smooth alternation of bacterial generations thereon in such a way that various kinds of microorganisms propagate at different propagating rates on the ceramic and may take off therefrom gradually with different senile involutions, while in the case of conventional plastic contacting medium a mass of bacterial layer falls off therefrom at the same time in consequence of formation of anaerobic bacterial zone.

A guide cylinder 50 having a lower conical separating skirt 51 is supported by a supporting column 52 in the treating tank 10. Said guide cylinder 50 forms therein a limited space wherein wastewater or raw water supplied from the top and air bubbles supplied from the bottom meet with each other. In said space a sufficient amount of oxygen is dissolved in wastewater or raw water and excess air is released into the atmosphere through a vent hole 21 provided in a top cover 21 of the tank. On the other hand, the wastewater or the raw water containing a sufficient amount of oxygen dissolved therein is pushed up by the air bubbles being supplied from the bottom and it flows over the top of the guide cylinder 50 into an upper portion of the multi continuous-pore soft ceramic 40,wherein the water flow down being subjected to biological treatment by bacteria. The water flowing out from the bottom of the multi continuous-pore soft ceramic 40 enters into the skirt 51 through the supporting column 52 and then it flows upwards

in the guide cylinder 50 together with air bubbles being supplied from an air bubble generator 30 and flows over to circulate through the soft ceramic 40 in the same way.

The air bubble generator 30 generates air bubbles from air supplied through a diffusing pipe 31 provided in the lower portion of the tank and feeds the air bubbles into the separating skirt 51. This air bubble generator is constructed not to allow the liquid supplied from the top of guide cylinder to flow down therethrough so that it can work reliably and also be completely protected during its stop.

The contacting element 40 of multi continuous-pore soft ceramic is secured to brackets 15 in the tank 10 by means of fixing plates 16. This element 40 may be used in any form as desired, for example, of a column, cylinder and the like so as to be fixed as formed on the brackets 16 with fixing plates 16 in the tank 10 or being of lumps, columns or grains so as to be placed in meshed package for fixing. Furthermore, the contacting element of multi continuous-pore soft ceramic material can provide a contacting surface of 2000 to 5000 m^2/m^3 which is 25 times that of conventional plastic honeycomb contacting element (max. 200 m^2/m^3). Therefore, when a tank having the same treating capacity as that of the conventional tank is constructed by use of said ceramic, an amount of contacting material required may be saved to 1/25 times that of the conventional plastic material, that makes it possible to greatly reduce the tank size to be suitable for use by each home, person and small or medium-size enterprise.

Fig. 3 is a sectional side view of another wastewater treating tank embodying the present invention (as a section taken along to line III-III of Fig. 4) and Fig. 4 is a sectional view taken along to line IV-IV of Fig. 3. Parts similar in function to those shown in Figs. 1 and 2 are designated by like numerals and explanations about them are omitted. In Figs. 3 and 4, the treating tank includes a plurality of contacting elements, each of which consists of two layers of cylindrically formed multi continuous-pore soft ceramic elements 40 which are fitted onto fixing rods 70 vertically placed on a supporting plate 60 secured to a guide cylinder 50. In case of applying plurality of layers of the multi continuous-pore soft ceramic elements 40 a cushioning material 80 is placed between two layers so as to protect the soft ceramic elements 40 from being damaged due to vibrations. The guide cylinder 50 is provided at its top with an air bubble reflux regulating sleeve 90 which serves a damping means for regulating reflux of air bubbles supplied from an air bubble generator 30. Numeral 61 designates reinforcing frame integrally made with the supporting plate.

In Figs. 3 and 4, there is shown a practical method of mounting cylindrical soft ceramic elements 40, however it will be readily understood that they may be installed at any desired place and the supporting plates may be also modified in their shape and arrangement depending upon the shape and place of the soft ceramic elements 40.

Fig. 5 is a sectional construction view for explaining

another water treating biological film tank embodying the present invention. In Fig. 5, the tank comprises three sections, i.e., a first (upper) section A, a second (middle) section B and a third (lower) section C. The first tank section functions in the same way as the treating tank previously described with reference to Fig. 1 or 3. Raw water such as lake water or the like is supplied through a raw water supplying pipe 21 into the first (upper) section A wherein it is subjected to treatment with aerobic bacteria on a biological film to get a normal BOD (biological oxygen demand), and then the water treated for BOD passes through an outlet 12 of the first section and enters into the second tank section B through an inlet 81 thereof.

In the second section B the water supplied through the inlet 81 is forcibly circulated by the action of pressurized fluid such as compressed air injected into the second tank section B through fluid supply nozzles 82 in order to separate sludge from the water by the action of centrifugal force produced therein. The water wherefrom the sludge was thus removed passes through a hole 83 provided in the second section's bottom and enters into the third tank section C. A hole 84 is used for removing air bubbles.

The third tank section C serves as a COD (chemical oxygen demand) treating portion wherein the water is subjected to treatment with anaerobic bacteria living in the presence and absence of oxygen. The third tank section C includes a ceramic cage 91 containing therein COD-treating contacting medium 90 of multi continuous-pore soft ceramic

material being the same as that used in the first section A. In the third tank section C, the water entered therein is diffused by the air bubbles supplied through an air feeding pipe and diffuser (air bubble generator) at the bottom of this tank section C and then it passes through the soft ceramic elements 90 wherein it is subjected to COD-treatment with the bacteria. The finally treated water is discharged from the third section C through an outlet hole 94. Excess air bubbles are discharged through an air bubble removing hole 95.

Accordingly, the third tank section C is similar in its construction to the first tank section A and differs from the first tank section A only by that it serves for water treatment for COD while the first section making water treatment for BOD.

The drinking water (treated lake water) that smells very musty can be completely deodorized through the biological film whereat planktons of phormidium/anabaena are decomposed by candida bacteria and ammonia are discomposed by nitrosomonas and nitrobacter bacteria.

As is apparent from the foregoing description, according to the present invention, it may be possible to provide a water treating biological film tank having a small size, which is low cost and requires little or no maintenance and no maintenance expenses, thereby being usable by each home, person or medium- or small-sized enterprise.

Although the invention has been described as related to

the embodiments for treating wastewater in home, it may be readily understood that the invention be not limited by the described embodiments, but rather be widely applicable for purification of industrial wastewater, general service wastewater, sewage water, intermediate wastewater and so on in order to make them usable as intermediate water or to protect lakes and rivers from being polluted as well as for treating various kinds of waters in the fields such as fisheries, food industries, brewing industry and so on.

It is also easily understood that the treating tank according to the present invention, although having cylindrical shape in the described embodiments, can be formed in any desired shape such as square and so on.

In the embodiment shown in Fig. 5, almost all sludge produced in each tank section are digested by biological films formed on the soft ceramic elements, that assures a high efficiency of water treatment therein.

Although the embodiment shown in Fig. 5, consists of three tanks vertically arranged on each other, it is also readily understood that a first-tank (tank A) and a second-tank (consisting of tanks B and C) or three tanks A, B and C may be arranged horizontally side by side.

The multi continuous-pore soft ceramic material will now be explained. This ceramic material, which is described in detail in the Japan laid open patent publication No. 107582/90, may be summarized as follows:

(1) Porous soft ceramic material composed of 65-93 wt.% SiO_2, 5.2-15.2 wt.% AL_2O_3 and 0.1-0.7 wt. % Fe_2O_3, which has

a network structure and pores of 20 to 120 µm in average diameter so as to be of apparent porosity of 60 to 80%.

(2) Porous soft ceramic material which in addition to the components described (1) contains 1.2-3.0 wt.% K_2O, 0.5-3.0 wt.% Na_2O, 0.5-2.0 wt.% CaO and 0.5-3.2 wt.% MgO.

(3) Porous soft ceramic material which contains the components described (1) and (2) and has a fine pores of 0.03 to 0.7 µm in diameter.

The above-mentioned porous soft ceramic materials (1), (2) and (3) can be manufactured in the following processes:

(1) combustible expandable resin and slurry composed of SiO_2, Al_2O_3 and Fe_2O_2 are mixed together, dried by air and then burned at temperature of not higher than 1100°C.

(2) combustible fine particles and/or fibrous materials and slurry composed of SiO_2, Al_2O_3 and Fe_2O_3 are mixed together, dried by air and then burned at temperature of not higher than 1100°C.

(3) Natural glass and slurry composed of SiO_2, Al_2O_3 and Fe_2O_3 are mixed together, dried by air and then burned at temperature of not higher than 1100°C.

Further, porous ceramic elements to be used in our invention shall contain components indicated in Table 1. Standard and more desirable conditions of the components are also given in Table 1. In Table 1, all figures are in percentages by weight (same as in Table No. 2).

Table 1 .

Component	Standard content	Preferable content
SiO_2	65 - 93	75 - 80
Al_2O_3	5.2 - 15.2	7.0 - 15.0
Fe_2O_3	0.1 - 0.7	0.1 - 0.3

If a porous ceramic contains SiO_2 beyond the standard content, it loses coagulating power and becomes to easily get out of shape. It is not desirable to burn the ceramic at higher temperature to prevent the shape losing since the ceramic surface is vitrified by burning to be unfavorable for bacterial growth thereon.

If a porous ceramic contains SiO_2 below the standard content, it can not realize taking-off of bacteria therefrom for alternation of generations, there fore bacteria become with time to be anaerobic resulting in the absence of aerobic bacteria in the porous ceramic element.

If a porous ceramic contains Al_2O_3 less than the standard value, it retards the bacteria's growth thereon resulting in death of them. On the contrary, if a porous ceramic contains Al_2O_3 more than the standard value, it may have less shear strength and therefore be easily bent.

If a porous ceramic contains Fe_2O_3 more than the standard value, it may repress the bacteria's growth thereon resulting in death of them. If a porous ceramic contains Fe_2O_3 less than the standard value, it may retard algae bacteria thereon.

It is further desirable that porous ceramic materials for use in the present invention contains components shown in Table 2 in addition to those shown in Table 1.

Table 2

Components	Desirable content	Best content
K_2O	1.2 - 3.0	1.2 - 2.5
Na_2O	0.5 - 3.0	0.7 - 2.0
CaO	0.5 - 2.0	0.7 - 1.5
MgO	0.5 - 3.2	0.5 - 2.0

If a ceramic contains K_2O and Na_2O_3 more than the desirable contents, algae bacteria may hardly breed thereon. If a ceramic contains K_2O less than the desirable contents, algae bacteria may breed thereon but slowly grow.

If a ceramic contains CaO more than the desirable content, there may be an undesirable effect that the fissiparity of protozoa becomes difficult. If a ceramic contains CaO less than the desirable content, protozoa may develop on the ceramic but be weak.

If a ceramic contains MgO more than the desirable content, there may be observed an undesirable tendency to prevent algae bacteria from growing. If a ceramic contains MgO less than the desirable content, in many cases algae bacteria may hardly develop on the ceramic.

Furthermore, porous ceramic materials for use in the present invention have therein open pores of specified size

at an apparent porosity of 60 to 80 or, preferably, 65 to 70.

Said apparent porosity of the ceramic is defined as follows:

$$\text{Apparent porosity} = \frac{\text{Volume of open pores (mercury forced into pores)}}{\text{Apparent volume of all solids}} \times 100$$

The soft ceramic elements for use in the present invention must be such that open pores in them have an average diameter of 20 to 120 µm, preferably 26 to 56 µm and more desirably 30 to 50 µm, but their shapes may not be especially limited.

CLAIMS

(1) A water treating biological film tank having therein a multi continuous-pore soft ceramic element being used as a treating biological film, and comprising a means for applying waste or raw water into the tank from the upper portion thereof, a means for forcing air bubbles into the tank from the lower portion thereof in opposition to the waste or raw water flow, the multi continuous-pore soft ceramic element placed around a space area wherein the waste or raw water and the air bubbles act counter to each other, an overflow outlet at the upper portion, a sludge draining outlet at the lower potion and a treated water outlet at a side wall of the lower portion, said treated water outlet being provided with water guiding partitions at its upper, front, right and left sides inside the tank so as to allow the treated water to be taken out from the bottom side only.

(2) A water treating biological film tank having therein a multi continuous-pore soft ceramic element being used as a treating biological film for treatment of water by using aerobic and anaerobic bacteria, and comprising a first-tank for treating waste or raw water with an aerobic biological film for BOD treatment, a second-tank for receiving the BOD treated water from the first tank and circulating said water to centrifugally separate sludge therefrom, and a third-tank for receiving the water from the second tank and treating said water with anaerobic biological film for COD treatment.

(3) A water treating biological film tank as claimed in

claim 2, wherein the first tank has a means for supplying waste or raw water for treatment at its upper portion, a means for supplying air bubbles in opposition to the waste or raw water at its lower portion, a multi continuous-pore soft ceramic around a space area wherein the waste or raw water and the air bubbles act counter to each other, a treated water outlet at a side wall of its lower portion.

(4) A water treating biological film tank as claimed in claims 2 or 3, wherein the second tank has a water inlet for receiving the treated water from the first tank at its upper portion, a fluid introducing port positioned under the water inlet and provided for introducing the water to be circulated in the second tank, and a water passage for transferring the treated water to the bottom tank.

(5) A water treating biological film tank as claimed in claims 2 or 3 or 4, wherein the third tank takes therein the water treated in the second tank, forces the water to circulate through a ceramic element for COD treatment and drain the finally treated water from the bottom side.

(6) A water treating biological film tank as claimed in any one of claims 2 to 5, wherein the three tanks are unitarily composed in vertical direction in such a way the first tank, the second tank and the third tank are arranged as an upper tank, an intermediate tank and a lower tank respectively.

(7) A water treating biological film tank as claimed in any one of claims 2 to 5, wherein the said tank is composed of the fist, the second and the third tanks horizontally arranged side by side in one unit.

(8) A water treating biological film tank as claimed in any one of claims 2 to 5, wherein the said tank is composed in such a way that the second tank and the third tank are vertically united with each other in one unit which is further horizontally connected with the fist tank to form an unitary tank.

(9) Apparatus for the biological treatment of waste water comprising

a vessel having an inlet for waste water opening downwardly into the vessel, an inlet for air adapted to generate air bubbles into the waste water and an outlet for treated water disposed in a lower region of a side wall of the vessel, and

a porous soft ceramic element adapted to support an aerobic microorganism and located within the vessel in the path of the aerated water flowing between the waste water and air inlets and the treated water outlet.

(10) Apparatus according to claim 9, comprising also a second vessel having a water inlet operatively connected to the treated water outlet of the biological treatment vessel and adapted to separate sludge centrifugally from the treated water, and an

outlet for treated water.

(11) Apparatus according to claim 2, comprising also a third vessel having a treated water inlet operatively connected to the treated water outlet of the second vessel and adapted further to treat the water with an anaerobic microorganism.

(12) Apparatus according to claim 1 or claim 9, substantially as hereinbefore described with reference to and as shown in Figs. 1 and 2 or Figs. 3 and 4 of the accompanying drawings.

(13) Apparatus according claim 2 or claims 10 and 11, substantially as hereinbefore described with reference to and as shown in Fig. 5 of the accompanying drawings.

atents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

Application number 9105122.7

Relevant Technical fields

(i) UK Cl (Edition K) C1C (CTBA,CSBA,CLC,CKC)

(ii) Int Cl (Edition 5) C02F

Search Examiner R.C. SQUIRE

Databases (see over)

(i) UK Patent Office

(ii)

Date of Search 2 July 1991

Documents considered relevant following a search in respect of claims 1,9,10,12

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	US 4931183 (KLEIN) - See particularly column 4 line 11	9
X	US 4454038 (SHIMODAIRA) - See particularly figure 2	9

SF2(p)

SJFABD

Category	Identity of document and relevant passages	Relevant to claim(s)

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

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E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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